FACTORS INFLUENCING THE AIR FORCE CYCLE ERGOMETRY FITNESS ASSESSMENT

THESIS

Heather M. Hunn, 1st Lieutenant, USAF

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DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

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FACTORS INFLUENCING THE AIR FORCE CYCLE ERGOMETRY FITNESS ASSESSMENT

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Heather M. Hunn

1st Lieutenant, USAF

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Heather M. Hunn
1st Lieutenant, USAF

Approved:

Peter T LaPuma | 1 Mar 01
Major Peter LaPuma (Chairman) | date
Assistant Professor, Systems and Engineering Management

Al W J | 1 MAR 01
Lieutenant Colonel Alan Johnson (Member) | date
Assistant Professor, Department of Operational Sciences

Daniel E. Reynolds | 1 Mar 01
Professor Daniel Reynolds (Member) | date
Assistant Professor, Department of Mathematics and Statistics

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Table of Contents

List of Figures

List of Tables

FACTORS INFLUENCING THE AIR FORCE

CYCLE ERGOMETRY FITNESS ASSESSMENT

I. Introduction

Background

The war-fighting capabilities of the United States military are directly dependent on the physical fitness of military members (Destadio, 1991:7). For this reason, the Department of Defense and each of its branches has taken a great interest in evaluating the fitness of U.S. military members (Pollock *et al.*, 1994:20). In the Air Force (AF), the concept of total body fitness is stressed and members are held to a higher level of fitness than the civilian population (DAF, 1997:1). The Air Force emphasizes the total body fitness concept because "inadequate physical fitness reduces performance ability, mobility, and physical endurance" (DAF, 1997:1), all of which are crucial war-fighting capabilities.

The Air Force promotes physical fitness by providing exercise facilities and educational programs on weight-loss, exercise, and smoking cessation (DAF, 1997:1). The physical fitness and weight of each AF member are assessed annually. Members who do not meet weight or fitness standards are placed into mandatory fitness programs designed to help them meet minimum AF standards. Members are placed in the Self-Directed Fitness Improvement Program (SFIP) after twice failing to meet minimum

standards on the physical fitness assessment. Members in the SFIP are retested within 180 days. If the member passes the physical fitness assessment, he or she is removed from the SFIP. If the member still does not meet standards after 180 days in the SFIP, he or she is placed in the Monitored Fitness Improvement Program (MFIP) for up to 180 days. If standards are not met within 180 days of placement into the MFIP, the member is referred to his or her commander for exemption or administrative action (DAF, 1998:24).

Besides the mandatory fitness programs, if the member fails to meet weight and fitness standards within a given time period administrative action and disciplinary measures may be taken. In the most severe cases, non-compliance with standards can result in separation or discharge from the military (DAF, 1998:22). It is up to the individual member to comply with fitness standards. With military careers at stake, it is important that the method of assessing physical fitness is valid and reliable.

The term physical fitness has many meanings, but generally it means improved physical performance as a result of an enhanced physiological capacity. Major components of fitness are cardiorespiratory endurance, muscular strength and endurance, flexibility, and body composition (Destadio, 1991:4). These components provide a basis to predict the body's ability to sustain intense exercise. Because it would be costly and time consuming to evaluate all these components, a measure of cardiorespiratory endurance, simply called aerobic fitness, is often used as an indicator of overall physical fitness. A common method of assessing aerobic fitness is through the measurement of VO_{2max}, or the maximum amount of oxygen the body can take up and use during exercise (Pollock *et al.*, 1994:9).

Through the 1970s and 1980s, Air Force members were required to run 1.5-miles within predetermined time limits as a test of aerobic fitness. The 1.5-mile run was administered annually. Although the 1.5-mile run test is an acceptable predictor of aerobic fitness (Pollock *et al.*, 1994:20), the test resulted in an estimated 2-5 fatalities a year (Smith and Flatten, 1997). The fatalities prompted Air Force leaders to seek a safer method of assessing physical fitness. In 1992, the Air Force eliminated the 1.5-mile run and began assessing physical fitness using a submaximal cycle ergometry test (SCET) using a stationary bike.

A submaximal test relies on a regression equation based on steady state heart rate, workload, and some additional factors to estimate VO_{2max}. There are some potential disadvantages with submaximal tests such as the Air Force's SCET. Any factors that influence heart rate will affect the prediction of VO_{2max} (Jackson and Ross, 1996:271). Studies have indicated that anxiety, stress, and substances such as caffeine and nicotine affect submaximal test results by altering heart rate. Because caffeine and anxiety increase heart rate, a submaximal test tends to underestimate VO_{2max} (Jackson and Ross, 1996:271).

It is also possible that the type and intensity of exercise a person regularly participates in will affect the predicted VO_{2max} with the SCET. For example, a runner may have a lower predicted VO_{2max} versus a cyclist who trains at a comparable intensity, duration, and frequency. This may occur because the cyclist trains specific muscles that optimize performance on a cycling fitness test such as the AF SCET.

Research Objective

The purpose of this study is to evaluate how Air Force members perform on the SCET in comparison to their degree of participation in different exercise activities such as running and bicycling. Furthermore, this study will evaluate the influence of other factors such as anxiety on an individual's SCET results.

Active duty Air Force members will be given a questionnaire after their normally scheduled annual SCET. Administration of the questionnaire after the member's annual SCET will allow test anxiety to be a factor when taking the SCET. Participants will be asked about their long- and short-term fitness routines, perceived fitness levels, perceived anxiety before and during the test, and selected personality traits. SCET results will be compared with self-reported training intensity and type of exercise for each participant.

II. Literature Review

It is well documented that a good measure of aerobic fitness is the extent to which the body is able to take up and use oxygen (Bassett and Boulay, 2000:214; Fitchett, 1985:85; Mitchell and Blomquist, 1971:1018). A fit individual can deliver and take up oxygen very efficiently. Aerobic fitness enhances overall health because:

> (a) low levels of cardiorespiratory fitness have been associated with a markedly increased risk of premature death from all causes and specifically from cardiovascular disease,
> (b) increases in cardiorespiratory fitness are associated with a reduction in death from all causes
> (c) high levels of cardiorespiratory fitness are associated with higher levels of habitual physical activity, which are, in turn, associated with many health benefits (Franklin, 2000:68).

When a person is subjected to increasing aerobic workloads, oxygen uptake will increase until a maximum quantity of oxygen uptake is reached. When the maximum oxygen uptake is reached, workload may be increased, but oxygen uptake will not increase beyond this point (Mitchell and Blomquist, 1971:1018). This point is called maximal oxygen uptake, or VO_{2max}. VO_{2max} is generally considered to be the best measure of physical fitness (Bassett and Boulay, 2000; Fitchett, 1985:85; Glassford *et al.*, 1965:309; Mitchell and Blomquist, 1971:1018).

VO_{2max} varies due to physiological differences between people such as age, body size, gender, and level of routine physical activity. VO_{2max} decreases as age increases (Fitzgerald *et al.*, 1997:161; Tanaka *et al.*, 1997:1949; Wilson and Tanaka, 2000:830) and VO_{2max} is proportional to body size (Mitchell and Blomquist, 1971:1020). Therefore, VO_{2max} is most commonly expressed as milliliters of O_2 per kilogram of body weight per

minute, ml/kg/min (Mitchell and Blomquist, 1971:1020). Expressing VO_{2max} as ml/kg/min normalizes the data for body weight and enables VO_{2max} measurements to be comparable among people of different body sizes. Females generally have 15-30% lower VO_{2max} values than males (Glenn, 1998:9). This is mostly due to the fact that women have smaller hearts, lower levels of hemoglobin, and less muscle mass (Glenn, 1998:9; Mitchell and Blomquist, 1971:1021).

VO_{2max} may also vary for an individual based on the time of day, diet, or amount of sleep (Pollock *et al.*, 1994:20). VO_{2max} also varies for women on oral contraceptives during different phases of their menstrual cycle. VO_{2max} was found to be slightly higher for women on oral contraceptives during the quasi-follicular stage of their menstrual cycle (MacAulay, 1999:45).

A prolonged increase in physical activity involving large muscle groups will increase VO_{2max} (Glenn, 1998:9; Mitchell and Blomquist, 1971:1021; Taylor *et al.*, 1955:76). This is because physical activity increases the body's ability to take in and use oxygen in muscles (Glenn, 1998:9). The increase in VO_{2max} as a result of training is dependent upon the duration and intensity of the exercise, as well as the baseline level of VO_{2max} for the individual.

Estimating VO_{2max}

There are three common ways to determine VO_{2max} for an individual. VO_{2max} can be measured directly with maximal tests, indirectly with submaximal tests, or with non-exercise tests. Maximal tests using a treadmill are considered the "gold standard" in VO_{2max} testing (Jackson and Ross, 1996:267; Smith and Flatten, 1997). Submaximal

tests indirectly estimate VO_{2max} using heart rate (HR), and non-exercise tests estimate VO_{2max} based on age, gender, body composition, and self-reported level of physical activity. Surprisingly, non-exercise tests have been shown to be as accurate and reliable as submaximal tests (Jackson and Ross, 1996:270). However, because they depend upon the truthful self-report of activity, they cannot be used when the individuals have an interest in the results, giving them a reason to falsify the self-reported activity levels.

Maximal Tests

Maximal tests can be performed on a treadmill or cycle ergometer (stationary cycle) while inspired and expired gases (O_2 and CO_2) are measured (Jackson and Ross, 1996:267; Smith and Flatten, 1997). Maximal tests require the individual to run or cycle at increasing workloads to exhaustion. Measuring VO_{2max} in this manner requires about 3-4 man-hours, the presence of medical personnel, and is estimated to cost up to $2,500 per test (Smith and Flatten, 1997).

Maximal treadmill tests are performed on motor driven treadmills, where power output can be regulated and easily quantified. Power output by the individual is regulated by treadmill grade and speed. Several treadmill maximal test protocols exist, but about 71% of all tests administered in the United States use the Bruce protocol (Jackson and Ross, 1996:267). The Bruce protocol does not involve collecting inspired and expired gases. Instead, VO_{2max} is estimated from total treadmill time of the test using a regression equation. VO_{2max} is highly correlated ($r \geq 0.90$) with the total time it takes to achieve maximal power output (Jackson and Ross, 1996:267). Treadmill speed and grade are

increased in 3-minute increments until the individual reaches voluntary exhaustion. The Bruce equation is as follows:

$$VO_{2max} = 13.30 - (0.30 \times TT) + (0.297 \times TT^2) - (0.0077 \times TT^3) + (4.2 \times CHS) \quad (1)$$

TT = treadmill time $\quad CHS$ = cardiac health status

Maximal tests performed on the cycle ergometer tend to produce VO_{2max} values that are significantly lower than those obtained on the treadmill (Basset and Boulay, 2000:218, Glassford *et al.*, 1965:511; Jackson and Ross, 1996:267). There are several possible reasons for this. It is likely that lower VO_{2max} values are a result of muscle fatigue in persons not accustomed to cycling. A maximal test may fatigue leg muscles before maximum VO_2 is reached. It is also possible that treadmill tests engage larger portions of muscle mass than bicycle tests do, resulting in higher VO_{2max} values (Glassford *et al.*, 1965:511; Jackson and Ross, 1996:267).

Maximal protocols where expired gases are measured generally have a standard error of ±1 ml/kg/min, and when VO_{2max} is estimated from treadmill time, as in the Bruce protocol, the standard error is generally ±3-4 ml/kg/min (Jackson and Ross, 1996:270). The direct measurement of gas exchange requires expensive and cumbersome equipment. Also, exercising a person to exhaustion can be dangerous. To avoid these problems, and the high cost that would be associated with testing all military personnel with the maximal treadmill test, the Air Force uses a SCET to estimate VO_{2max}.

Submaximal Tests

Submaximal tests are most often performed on a cycle ergometer, although they can be performed on a treadmill or a track. Submaximal tests are faster, safer, and

cheaper to perform than maximal tests. However, submaximal tests have been found to be less accurate than maximal tests (Hermansen and Saltin, 1969:33; Jackson and Ross, 1996:267). Submaximal tests based on HR tend to estimate VO_{2max} within 10-20% of maximally determined VO_{2max} (Pollock, 1994:20).

In a submaximal test, one or more HR measurements are taken throughout the test as power output of the individual is increased. The HR measurements, power output, and some additional factors are entered in a regression equation to determine the slope of the individual's HR. VO_{2max} is estimated by extrapolating the HR slope to maximal HR and the corresponding VO_{2max} (Jackson and Ross, 1996:267). Submaximal power outputs are defined as outputs that elicit a HR response between 45% and 70% of an individual's HR at VO_{2max} (Jackson and Ross, 1996:268). When at submaximal power outputs, the stroke volume (the volume of blood pumped by the heart per heart beat) levels off and does not influence VO_{2max} (Jackson and Ross, 1996:268). Below 45% of VO_{2max}, stroke volume contributes to changes in oxygen uptake; above 70% of VO_{2max}, anaerobic metabolism occurs, and aerobic metabolism is of interest when measuring VO_{2max} (Jackson and Ross, 1996:268).

Submaximal test results are only valid if four assumptions are met. First, a linear relationship between oxygen consumption and HR exists and is constant. This assumption is true within 10-85% of VO_{2max} (Mitchell and Blomquist, 1971:1019; Pollock *et al.*, 1994:19). The second assumption is that individuals of the same age have similar maximum heart rates. Maximum HR is predicted by subtracting the individual's age from 220. For example, a 30-year-old individual's maximal HR would be 220 - 30 = 190 beats per minute (bpm). This second assumption is not always true. Maximal HR

has been shown to vary up to ±25 bpm for individuals of the same age and gender (Pollock *et al.*, 1994:20). The third assumption is that all individuals have similar cycling efficiencies. There is some variation among individuals depending on the ergometer used and the seat height of the ergometer; these variations can result in predicted VO_{2max} values that vary by ±6% (Pollock *et al.*, 1994:20). The fourth assumption is that there is no day-to-day variation in HR. This assumption is not always true either. Pollock *et al.* state that day-to-day variation in HR can be as much as ±5 bpm. In addition to the daily variation in HR, drugs, caffeine, eating, nicotine, amount of sleep, time of day, room temperature and humidity, anxiety, and numerous other factors can alter HR (Jackson and Ross, 1996:271; Pollock *et al.*, 1994:20).

If one of these assumptions is not met, the reliability of VO_{2max} estimation could be compromised. It is easy to see how complex the estimation of VO_{2max} is when using HR to predict VO_{2max}.

Astrand-Rhyming Nomogram

The Air Force's SCET is based on a nomogram first developed by Astrand and Rhyming. The Astrand-Rhyming (A-R) protocol is a submaximal test of aerobic fitness developed in 1954 and in 1960 the protocol was revised for age factors. The A-R protocol requires one trained technician, a stationary cycle, and a HR monitoring device to complete the test. Individuals pedal at 50 revolutions per minute (rpm) at a predetermined workload based on age, body size, and gender. For the test, individuals pedal for six minutes and HR is taken. If at the end of the sixth minute, HR is between 45% and 70% HR at VO_{2max}, the test ends, and VO_{2max} is estimated using the A-R

nomogram based on the HR measurement, age, weight, and the corresponding power output. If HR is below 45%, power output is increased and the test continues for another three to six minutes. HR measurements are taken at the end of each minute until a steady state HR is reached. Steady state HR defined as two HR measurements within ±5 bpm (Jackson and Ross, 1996:268). VO_{2max} is then estimated using the nomogram based on age, weight, steady state HR, and the ending power output.

The A-R regression equation was developed with 27 male and 31 female well-trained, healthy individuals 20-30 years of age. The standard error of A-R predicted VO_{2max} compared to maximally determined VO_{2max} was greater at lower workloads than at higher workloads (Astrand and Rhyming, 1954:220). Furthermore, there was a larger degree of variance between individuals when VO_{2max} was predicted using the A-R equation compared to maximally determined VO_{2max}. Increased variance is a concern because it decreases the reliability of the submaximal test in predicting VO_{2max}.

Many studies indicate that the submaximal test using the A-R protocol underestimates VO_{2max} measured by the maximal treadmill test. Reported under-estimations range from 10% to 20% (Fitchett, 1985:86; Rowell *et al.*, 1964:926; Storer *et al.*, 1990:711). In 16 studies the correlation coefficients between the maximally determined VO_{2max} and the A-R submaximally determined VO_{2max} ranged from 0.47 to 0.92 (Pollock *et al.*, 1994: 24-26).

One study reported no significant difference in the mean VO_{2max} values obtained using the maximal treadmill and submaximal cycle A-R protocols (Glassford *et al.*, 1965:511). But this study did conclude that variance is significantly greater with the A-R

test compared to the maximal treadmill test, further questioning the reliability of using the submaximal A-R protocol.

Evidence presented here suggests that submaximal testing underestimates maximally determined VO_{2max}. Because the A-R protocol was developed with well-trained, young individuals, there is some concern about the validity of the SCET when used to test larger populations containing moderately fit or older individuals.

Air Force Fitness Testing

The Air Force's SCET is a modification of the A-R protocol. The SCET takes a total of about 14 minutes and does not require medically trained personnel (Smith and Flatten, 1997). The technician enters height, weight, and age information into the computer. The member wears a wireless HR monitor just below the chest, which relays continuous HR information to the computer during the test. At the end of each minute of the test, the HR is recorded. The resulting VO_{2max} is calculated by the computer using regression and is based on age, gender, height, weight, steady state HR, and final workload setting on the cycle.

AF members are instructed not to consume nicotine (one hour prior) or caffeine (two hours prior) and to limit food intake (one hour) prior to the test. Test procedures are as follows. The member rests for two minutes before pedaling begins. Heart rate is monitored as the member pedals at 50 rpm during the entire test. Beginning workload (cycle resistance) is based on age, gender, weight, and self-reported exercise habits. This workload is continued for the first three minutes of the evaluation. During the next five minutes of the test, workload may be increased at minutes four, six, and eight to

gradually increase the member's HR to within 45-70% of their VO_{2max}. HR is recorded at the end of each minute, and when the member has pedaled six minutes at the same workload the last two HR measurements are compared. If the last two HR measurements are within 5 bpm of each other the test is complete, the two HR measurements are averaged, and VO_{2max} is calculated. If the last two HR measurements are not within 5 bpm of each other, the test continues and another HR measurement is taken at the end of the additional minute. If two of the three HRs are within 5 bpm of each other, VO_{2max} is estimated as indicated above. After the test is complete, the individual pedals until HR falls below 120 bpm (USAF FPOb, 2000).

There are three possible outcomes of the AF SCET. A member can receive a pass, fail, or invalid rating. To pass the test, the member must have pedaled at 50 rpm and the ending HR must have been greater than 125 bpm but less than 85% of his or her calculated maximum HR. Also, HR must have reached a steady state (USAF FPOb, 2000). To receive a failing score, all the above must have occurred but the member's estimated VO_{2max} score was below AF standards. An invalid test can occur for various reasons. For example, an invalid rating occurs if the HR monitor slips off an individual, or if an individual exceeds his or her maximum HR. An invalid rating means that a VO_{2max} score could not be assessed, but it is not a failing score. Table 1 shows the AF minimum SCET standards for age and gender.

Table 1 - Air Force standards for submaximal cycle ergometry fitness testing

Minimum VO_{2max} score needed to meet AF Fitness Standards (ml/kg/min) Percentiles shown are for maximally determined VO_{2max}				
Age in Years	Females	Percentile	Males	Percentile
<24	27	<10%	35	10%
25-29	27	<10%	34	10%
30-34	27	15%	32	10%
35-39	26	10%	31	<10%
40-44	26	20%	30	10%
45-49	25	10%	29	<10%
50-54	24	20%	28	10%
55-59	22	10%	27	<10%

Adapted from DAF, 1998:21 and Franklin, 2000:77

Factors Affecting Submaximal Prediction

As stated earlier, VO_{2max} estimated with a submaximal test can vary day-to-day for an individual. Anything that alters HR can alter submaximal test results. HR can be altered by pedaling frequency, cycling experience, seat height, drugs, nicotine, caffeine, anxiety, and phase of menstrual cycle for women on oral contraceptives.

Pedaling frequency has been shown to affect prediction of VO_{2max} in submaximal tests. One study demonstrated that higher estimated VO_{2max} was achieved at 60-70 rpm versus 40-50 rpm (Hermansen *et al.*, 1969:37). However, another study (Swain and Wright, 1997:269), demonstrated that for 30 experienced cyclists and 28 nonexperienced cyclists there were no significant differences in VO_{2max} or peak HR when pedaling at 50 and 80 rpm.

Due to differences in leg lengths between individuals, proper seat height adjustment for the submaximal cycle test is important. Adjusting the seat according to height and leg length will ensure efficient and economical work (efficient power output from energy input). Inefficient work as a result of seat height will result in underestimation of VO_{2max} (Pollock *et al.*, 1994:29). Astrand and Rhyming reported as much as ±5.9% standard deviation of the mechanical efficiency of cycling for women, and ±4.6% for men (Astrand and Rhyming, 1954:219).

Caffeine, nicotine, or other medications or drugs that alter HR can affect estimation of VO_{2max}. Caffeine increases HR, while nicotine decreases HR response to exercise. Therefore, caffeine would tend to underestimate VO_{2max} while nicotine could overestimate VO_{2max} (Glenn, 1998:18; Pollock *et al.*, 1994:29-30).

For women on birth control pills, SCET VO_{2max} values were found to be significantly higher during the quasi-follicular phase (3 weeks of the month during which synthetic hormones are taken) than during the quasi-leutal (menstruation) phase (1 week of the month when a placebo is taken). Even when tested during the quasi-follicular phase, the SCET underestimated maximal treadmill VO_{2max} by an average of 5% (MacAulay, 1999:35).

Effects of Training

While there is general agreement that VO_{2max} is a good predictor of aerobic fitness (Bassett and Boulay, 2000:214; Fitchett, 1985:85; Mitchell and Blomquist, 1971:1018), the VO_{2max} estimated by the SCET may vary depending on training intensity or which training method is used to enhance aerobic fitness. The maximally determined VO_{2max}

for a young aerobically trained male (such as an Olympic endurance athlete) is about 75-80 ml/kg/min, while the maximally determined VO_{2max} of a healthy, moderately active 20-year-old male is about 45 ml/kg/min (Mitchell and Blomquist, 1971:1021). "Values above 55 ml/kg/min are rarely recorded among subjects who do not train regularly" (Mitchell and Blomquist, 1971:1021).

Cyclists may experience a training effect when taking the SCET. That is, they may be at an advantage over non-cyclists because they can achieve a higher cycling efficiency (power output from energy input) due to their training routine. Nickleberry and Brooks state the theory as, "Local muscle adaptations or more efficient recruitment patterns of leg musculature engendered from previous cycling experience would allow for improved whole body muscular efficiencies" in competitive cyclists (Nickleberry ad Brooks, 1996:1397).

An extension of the above theory is that individuals who cycle as a regular aerobic activity develop "greater recruitment of more efficient Type I muscle fibers during exercise" (Nickleberry and Brooks, 1996:1400). Muscles have Type I (slow-twitch) and Type II (fast-twitch) fibers. Type I fibers can sustain long contractions without fatigue and Type II fibers cannot sustain long contractions. Type I fibers have a larger blood supply, a larger supply of energy, and an increased delivery of oxygen to the muscle fibers than Type II fibers. Type I muscle fibers also resist fatigue longer than Type II fibers (Fox, 1999:350-351). Increased recruitment of Type I fibers due to training would improve SCET performance due to the structural advantages of Type I fibers for aerobic tests.

Findings cited by Basset and Boulay suggest "VO_{2max} values are dependent upon the mode of exercise and the specific training of an athlete" (Basset and Boulay, 2000:218). One study investigated differences in maximally determined VO_{2max} on the treadmill and cycle ergometry for well-trained runners, cyclists, and triathletes. Maximal treadmill VO_{2max} was 2.8% higher for cyclists, 6.1% higher for triathletes, and 10.5% higher for runners than maximal cycle test VO_{2max} (Basset and Boulay, 2000:218).

Rowell *et al.* found that the A-R nomogram was a better predictor of VO_{2max} for endurance-trained athletes such as distance runners and competitive swimmers than for non-endurance-trained individuals. The VO_{2max} predicted by the A-R nomogram was 3.7% lower than maximal treadmill VO_{2max} for a group of endurance-trained athletes. The A-R VO_{2max} scores were 21% lower for non-endurance-trained individuals, suggesting significantly reduced reliability of VO_{2max} A-R prediction for non-endurance trained athletes (Rowell *et al.*, 1964:924, 926). These findings may be the result of using well-trained athletes to develop the A-R nomogram.

Another study tested low-fit (maximally determined $VO_{2max} < 35$ ml/kg/min for males and < 29 ml/kg/min for females) and high-fit males and females (maximally determined $VO_{2max} \geq 44$ ml/kg/min for males and ≥ 37 ml/kg/min for females) using the SCET and a maximal treadmill test. For low-fit males, SCET estimated VO_{2max} was 5.8 ml/kg/min (15.4%) lower than maximal treadmill VO_{2max}, but for high-fit females SCET VO_{2max} was higher by 5.5 ml/kg/min (14.6%). There were no significant differences between the tests for high-fit males or low-fit females (Pollock *et al.*, 1994:103). Pollock *et al.* state that "lower r [correlation] values and the higher relative SEE [standard errors of estimate] values as well as the significant under estimation of VO_{2max} compared to the

treadmill VO_{2max} make the validity of the [SCET] equation questionable for use in lower-fit males" (Pollock et al, 1994:83). In the same study, estimated VO_{2max} scores for cyclists versus non-cyclists were compared. Male cyclist results showed significantly higher SEE values than non-cyclists, questioning the validity of the SCET when testing male cyclists (Pollock *et al.*, 1994:88).

There is also some evidence suggesting that the mode of training should be considered when deciding whether to determine VO_{2max} using a treadmill or a cycle ergometer. "Training effects also appear to be specific to the mode of training used by an athlete… Because of this specific adaptation, runners are generally tested on a treadmill, and cyclists on a cycle ergometer," (Basset and Boulay, 2000:214).

The research concerning the effects of training on SCET prediction of VO_{2max} seems to indicate that submaximal assessments of VO_{2max} may favor cyclists and are more accurate predictors of VO_{2max} for highly trained individuals than for moderately trained individuals. This suggests that the AF SCET may not be the best predictor of VO_{2max}.

<u>Effects of Age and Training</u>

A meta-analysis of VO_{2max} scores for 4,884 women separated into sedentary, active, and endurance-trained groups found that VO_{2max} declined with age for all three groups but declined at the greatest rate in the endurance-trained group (Fitzgerald *et al.*, 1997:160). A follow-up study tested the VO_{2max} of 156 women divided into two groups: sedentary and endurance-trained runners. Consistent with the meta-analysis by Fitzgerald, the rate of decline in VO_{2max} with age was significantly lower for sedentary

women than for the endurance-trained runners (Tanaka *et al.*, 1997:1947). Contrary to the Fitzgerald *et al.* and Tanaka *et al.* studies, another meta-analysis of male individuals showed that absolute rates of decline of VO_{2max} did not differ between sedentary and active groups of men (Wilson and Tanaka, 2000:829).

Situational Effects

Situational factors surrounding the SCET could easily influence SCET performance. Two situational factors, test anxiety and perceived validity of the SCET, will be examined for their effects on SCET performance.

Anxiety about the test itself could alter the outcome of the AF cycle ergometry test by altering HR. It is also possible that life stressors could indirectly alter VO_{2max} prediction by causing changes in sleeping habits, eating habits, or use of caffeine, nicotine, or other drugs. If these changes affect HR, VO_{2max} score on a submaximal test could be altered. "Pulse rate can vary... directly with the emotional state or degree of excitement of the subject" (Rowell *et al.*, 1964:920).

The human body has two basic responses to stress: immediate and prolonged. Both responses involve the autonomic nervous system (ANS). In response to an immediate stressor, the ANS "speeds up the rate, strength and regularity of the heart beat" (Dobson, 1983:111). It also stimulates the release of glucose to provide energy, directs blood to the muscles and brain, dilates the bronchioles to aid in respiration, and triggers many other physiological changes (Dobson, 1983:111). Test anxiety is an immediate stressor on the individual that is likely to cause an ANS response. If an individual experiences test anxiety before or during the SCET, the physiological

responses listed above are likely to occur, resulting in an underestimation of VO_{2max} due to an increased HR caused by test anxiety. Because disciplinary action can result if AF members do not meet the standards for fitness, the SCET creates a tense situation where an individual could be nervous or anxious during the test.

No studies were found that examine how stress and anxiety affect the results of submaximal or maximal tests of aerobic fitness. However, there is some evidence that individuals who report low anxiety levels demonstrate superior performance on simple and easy learning tasks over individuals who report high anxiety levels (Heinrich and Spielberger, 1980:146). High test anxiety has been associated with poor performance on cognitive tasks. When individuals take timed tests or when they are told their performance will be observed by others, individuals with higher test anxiety tend to do poorly on tests while individuals with lower test anxiety tend to do well on cognitive tests (Dweck and Wortman, 1980:97).

Test anxiety was chosen as a factor that may affect SCET results based on the premise that the relationship between better test performance and low anxiety may hold true for physical performance as well as cognitive performance. Low anxiety could result in high physical performance on the SCET.

An individual's perception of the validity of the SCET may also influence SCET results. If a person regards the SCET as a valid test of aerobic fitness, he or she may exert more effort to pass the test. Individuals who feel in control over the outcome of a test have been shown to have more intensive emotional reactions to a test (Becker, 1980:277). Thus, if the test is viewed as valid and results are viewed as controllable, test anxiety could be increased, resulting in an increased HR. On the other hand, perceived

validity of the SCET may result in increased confidence in individuals. Either way, a person's perception of the validity of the SCET may affect results.

Personality Effects

It is also possible that personality could affect performance on the SCET. For example, a person with an anxious personality (trait anxiety) may perform poorly under stress. Also, if a person is very anxious as a part of their personality, he or she may be easily influenced by test anxiety.

The field of personality research generally categorizes personality traits into five dimensions commonly referred to as the "Big Five" (John and Srivastava, 1999:103). The "Big Five" are described below.

I. Extraversion or Surgency (talkative, assertive, energetic)
II. Agreeableness (good-natured, cooperative, trustful)
III. Conscientiousness (orderly, responsible, dependable)
IV. Emotional Stability versus Neuroticism (calm, not neurotic, not easily upset)
V. Intellect or Openness (intellectual, imaginative, independent-minded)

(John and Srivastava, 1999:105)

One of the most commonly used approaches to studying the "Big Five," published by Costa and McCrae in 1992, is the NEO Personality Inventory-Revised, NEO PI-R (John and Srivastave, 1999:110). The NEO PI-R survey measures each of the "Big Five" personality traits by measuring the degree to which an individual expresses parts, or facets, of each trait (John and Srivastave, 1999:14, 110). For example, the six facets for Emotional Stability (IV above) are anxiety, angry hostility, depression, self-consciousness, impulsiveness, and vulnerability (John and Srivastave, 1999:16).

Two specific personality facets that were hypothesized to be relevant to SCET performance were selected for evaluation. From the dimension of Conscientiousness, the achievement striving facet was chosen, and from the dimension of Neuroticism, the anxiety facet was chosen. The anxiety facet will be called trait anxiety to separate it from test anxiety. Achievement striving and trait anxiety were chosen because it is hypothesized that these two facets would most likely influence the results of the SCET.

An individual who scores high on achievement striving works hard to achieve goals and has high levels of aspiration (Costa and McCrae, 1992:18). "Individuals differing in achievement motivation show the greatest differences in anxiety and concern about achievement in a course when this course is seen as important to a student's long-term goals" (Dweck and Wortman, 1980:93). Thus, if an individual sees the SCET as an important aspect to their long-term goals, they may experience greater anxiety about the test, resulting in poor performance on the SCET, possible due to an increased HR. Although high achievement striving could result in increased anxiety about the SCET, there is some evidence that suggests that low achievement striving could result in poor performance because the individual believes he or she does not control the outcome of the SCET. Individuals who are low in achievement striving "should perform most achievement tasks with relatively little intensity or vigor since they believe that their performance is less likely to be affected by their efforts" (Dweck and Wortman, 1980:96).

The second facet, trait anxiety, will help determine if having an anxious personality has any affect on test performance. This facet measures the general anxiousness of an individual. The NEO PI-R test manual states, "Individuals who score

low on Neuroticism are emotionally stable. They are usually calm, even-tempered, and relaxed, and they are able to face stressful situations without becoming upset or rattled" (Costa and McCrae, 1992:15). Low scorers tend not to worry about things that may go wrong (Costa and McCrae 1992:16). Individuals who score high on the trait anxiety facet are tense, nervous, and jittery. Having an anxious personality could cause heart rate to be increased during a stressful situation, resulting in an underestimation of VO_{2max}. This idea is summarized nicely by Heinrich and Spielberger, "Persons high in trait anxiety tend to perceive a greater number of situations as more dangerous or threatening than persons who are low in [trait anxiety] and to respond to threatening situations with [trait anxiety] elevations of greater intensity" (Heinrich and Spielberger, 1980:148). It is theorized that a participant who scores high on the trait anxiety facet will perform poorly on the SCET.

<u>Research Questions</u>

This research will evaluate the following four questions.

(1) Is there a relationship between situational factors and SCET VO_{2max}?
(2) Is there a relationship between personality and SCET VO_{2max}?
(3) Is there a relationship between exercise activities and SCET VO_{2max}?
(4) How much variance in SCET VO_{2max} scores is explained by the variables in questions 1-3?

These questions were formed on several premises. The first and second questions will determine if situational factors (test anxiety and perceived validity of the SCET) or personality facets (trait anxiety and achievement striving) influence SCET VO_{2max}. Test anxiety would tend to increase HR, underestimating VO_{2max}. An anxious personality may

increase the individual's response to test anxiety, increasing HR. It is hypothesized that higher levels of any type of anxiety will result in lower VO_{2max} scores due to higher HRs.

The answer to the third question will determine whether the type of exercise performed influences SCET VO_{2max}. For example, cyclists may have an advantage in the AF SCET over individuals who primarily run. This may be due to the fact that cyclists are directly training the muscles involved in cycling.

The answer to four will determine what variables are significant predictors of VO_{2max} as estimated by the SCET. Significant predictors will be identified through stepwise multiple regression. It is hypothesized that test anxiety level will be a significant predictor of VO_{2max}, since individuals are likely to be anxious about the SCET due to the serious consequences associated with failing to meet AF standards. Question four will also identify the proportion of variance in SCET VO_{2max} scores explained by the significant predictors.

The sources of variance in VO_{2max} scores for different subsets of the sampling population will also be identified. Are there different predictors of VO_{2max} for runners and cyclists? Are the proportions of explained variance in VO_{2max} scores similar for different groups?

III. Methodology

Data were collected from a cross-sectional sample using a traditional paper-and-pencil questionnaire, which is found in Appendix A. The purpose of the questionnaire was to measure the influence of test anxiety, personality, exercise type, and exercise intensity. These data were used to determine the extent to which these factors influenced an individual's SCET results.

The questionnaire was approved by the Air Force Personnel Center and was assigned survey control number SCN 00-87. Personnel at the Wright-Patterson AFB Health and Wellness Center (HAWC) granted permission to administer the survey to participants after the member's annual SCET was completed.

AFIT military personnel, both students and faculty, took the AF SCET during a six-week period in September and October 2000. The survey was administered after the participants completed their annually required SCET to avoid influencing performance on the SCET. The AFIT Fitness Assessment Monitors who administered the SCET offered the survey to approximately 500 AFIT personnel. The survey was voluntary and participants were assured confidentiality. The purpose, confidentiality, and contact information were disclosed to the participants in the cover sheet of the survey.

Data Collected

The data can be broken down into the following seven categories, which are described in the following sections.

(1) Demographic data
(2) Exercise activity during the past four weeks and the past six months
(3) Perceived test anxiety of the participant before and during the SCET
(4) Perceived aerobic and overall fitness of the participant
(5) Participant's perception of the validity of the SCET
(6) Participant's SCET score and SCET score history
(7) Personality facet assessments (achievement striving and trait anxiety)

Demographic Data

The first section of the survey asks the participant to provide information concerning his or her gender, age, weight, and height. The first letter of the participant's last name as well as the last four digits of their social security number were collected so that VO_{2max} scores reported by participants could be checked against the VO_{2max} scores provided by the HAWC. The participants were assured that this personal information would be deleted after the scores were matched to the survey data.

Exercise History

Participants were asked to provide data for their average weekly exercise routine during the past four weeks and the past six months prior to the SCET. The six-month (6M) data was collected to determine the long run average exercise activities of the participants. The four-week (4W) data was of interest to see if individuals increase their levels of exercise in the weeks prior to the SCET in preparation for the SCET. Both the 6M and the 4W exercise data were collected as the participant's average weekly output per activity type. Information was collected about the duration and frequency of the activities the individual participated in (See Appendix A for more information).

To evaluate whether participants shifted their exercise routines because of the upcoming SCET, it was necessary to collect both short-term (4W) and long-term (6M) exercise histories. It was theorized that individuals who increase their level of exercise prior to the SCET would perform better than individuals who do not increase their level of exercise prior to the SCET.

Each participant's average weekly activities, intensities, and durations were collected and converted to kilocalories (kcal) per week so that data could be compared between exercise activities. Conversion to kcals was accomplished using metabolic equivalents (METs). One MET is equivalent to the resting metabolic rate of an adult (Ainsworth, 1993:72). Ainsworth *et al.* published MET values for numerous physical activities to include common methods of exercise. Energy expenditure was calculated by multiplying the MET value for a specific exercise intensity by the participant's weight in kilograms and the hours of the particular exercise (Ainsworth *et al.*, 1993:73). The calculation of kcals is shown below in Equation 3. This equation assumes the resting metabolic rate of an adult equals one kcal per kilogram (kg) of body weight per hour of activity. The MET value assigned to an activity is a multiple of the resting metabolic rate and so the units of each MET are kcals per kg per hour.

$$kcal = (METs) \times (kg\ body\ weight) \times (hours\ of\ activity) \tag{3}$$

$$1\ MET = \frac{1\ kcal}{1\ kg\ body\ weight \bullet 1\ hour\ of\ activity}$$

For example, if an 80kg male ran 3 hours per week at 7 mph (MET = 11.5), then energy expended = (11.5 METs) x (80 kg) x (3 hours) = 2,760 kcals. Converting exercise data into kcals using METs was recommended by the American College of Sports Medicine

and other professionals in the exercise science field as a method of assessing caloric expenditure (Franklin, 2000:153).

Besides collecting data with the questionnaire (Appendix A), the four-week exercise data were also collected on a weekly basis via e-mail from 59 AFIT volunteers during the four weeks prior to the SCET. Collecting exercise data on a weekly basis is more accurate since participants only need to recall one week of activity versus four weeks of activity at the time of the SCET. The purpose of collecting weekly information was to determine if there would be an appreciable difference in the results based on the two types of collection methods. To test the level of accuracy of the data collected four times a month via e-mail versus data collected once a month via the paper survey, the e-mail data and the 4W questionnaire data (excluding the e-mail participants) will be entered in a stepwise multiple regression. This analysis will help determine the level of influence that data collection frequency had on the results.

All exercise data was handled in the same manner by converting to kcals per week using the MET conversion described above. The same 59 volunteers also completed the questionnaire administered after the SCET.

Situational Factors

The second section of the questionnaire contained ten questions. The participant indicated their agreement with each item based on a six-point Likert scale ranging from (1) strongly disagree to (6) strongly agree. Three areas were examined in this section: test anxiety, perceived fitness, and perceived validity of the SCET. For each area, multiple questions were used to increase measurement reliability (Dooley, 1995:143).

Some of the items in each area were reversed to encourage participants to carefully read each question.

Questions 1, 4, and 10, shown below, measured the participant's anxiety about the SCET (test anxiety). These items were included to test the hypotheses that test anxiety is an important influence on the performance on the SCET. A reliability estimate was calculated for the set of questions using Cronbach's alpha ($\alpha = 0.88$), and none of the items were deleted. Cronbach's alpha ($0 \leq \alpha \leq 1$) measures the internal reliability of the questions. A high alpha indicates that the questions were measuring the same idea.

1. I felt relaxed about the cycle ergometry test just before I took the test. (Reversed)
4. I was anxious about the fitness test the week prior to the test.
10. I was anxious about the possibility that I would not pass the fitness assessment.

Three other questions (3, 7, and 9 shown below) were intended to rate the participant's perceived fitness level. Reliability analysis was conducted using Cronbach's alpha ($\alpha = 0.25$), and after careful review, these items were deleted due to low reliability.

The remaining four questions (2, 5, 6, and 8 shown below) refer to the participant's perception of the validity of the SCET. Reliability analysis for these items was conducted using Cronbach's alpha ($\alpha = 0.83$), and none of the items were deleted.

2. I believe the cycle ergometry test is a valid test of my aerobic fitness level.
5. I can improve my score on the cycle ergometry fitness assessment if I exercise more frequently.
6. The cycle ergometry fitness assessment is a good predictor of my aerobic fitness level.

8. There is little I can do to improve my performance on the cycle ergometry fitness assessment. (Reversed)

Factor analysis was also conducted on the test anxiety and validity questions using principal component analysis. The Rotated Component Matrix is located in Appendix B. The factor analysis confirmed that the three test anxiety questions were measuring the same idea and the four perceived validity questions were measuring the same idea.

SCET History and Score

Questions 11-14 (see Appendix A) are intended to collect data about the participant's SCET history. For example, participants were asked whether they had received an invalid or below passing score on the SCET and when those results occurred. Also, participants were asked if they had ever been in the Self-Directed or Monitored Fitness Improvement Programs (SFIP and MFIP), and the years they were in the programs, if any. This data will be used to examine possible relationships between test anxiety and past performance. It is theorized that prior difficulties in passing the SCET will cause increased test anxiety.

The participants were also asked to provide their current score on the SCET and whether it was a passing, invalid, or failing score. The VO_{2max} score reported by each participant was crosschecked against a master list of scores provided by the Wright-Patterson HAWC. In general, participants accurately reported the SCET score they received the day of the test.

Personality Facets

The NEO PI-R achievement striving and trait anxiety questions constitute the final sixteen questions of the survey. There are eight questions per personality facet. Participants are asked to indicate their agreement with the questions based on a seven-point Likert scale ranging from (1) strongly disagree to (7) strongly agree. These items were reproduced with special permission of the publisher, Psychological Assessment Resources, Inc. Because these items are copyrighted, they do not appear in Appendix A with the rest of the questionnaire. The NEO PI-R item scores for each facet were averaged to form an overall score for each facet.

Factor analysis for the NEO PI-R items was conducted, and the Component Matrix can be found in Appendix B. The trait anxiety and achievement striving questions separated into two factors, as expected, indicating that the questions were measuring the same construct. Reliability analysis of the items resulted in Cronbach's $\alpha = 0.83$ for the anxiety items. For the achievement striving facet, question 26 on the survey was deleted, resulting in $\alpha = 0.72$. From these results, the items were determined to be reliable.

Method of Analysis

Because it was theorized that other variables besides actual physical fitness contribute to VO_{2max} assessment, multiple stepwise regression was chosen to determine the relative influence of each variable on SCET VO_{2max} score. Multiple stepwise regression was also used to determine which factors explain the most variance in VO_{2max} scores.

The dependent variable in the regression is ΔVO_{2max}. ΔVO_{2max} is the SCET VO_{2max} score minus the AF established minimum passing score relative to the participant's age and gender. For example, if $\Delta VO_{2max} = 0$, the individual matched the minimum AF standard. A positive ΔVO_{2max} would indicate that the individual performed better than the AF standard, and a negative ΔVO_{2max} would indicate that the individual performed worse than the AF standard. The ΔVO_{2max} score is a more comparable measure of a person's fitness level because it corrects for the influence of age and gender using the AF standards.

The exercise data, expressed as average kcals expended per week (variables 1-6 below), were entered into the regression in several different ways to determine if there were any certain activities which were better predictors of ΔVO_{2max} than others. For example, the data was grouped into aerobic and anaerobic activities to measure the relative influence of each on ΔVO_{2max}. Also, specific exercise activities, such as running and cycling, were entered separately to determine which activities were better predictors of ΔVO_{2max} than others. The independent variables entered into the multiple stepwise regression were as follows:

(1) 4W aerobic kcals from the questionnaire (2) 4W aerobic kcals from e-mail (3) 4W anaerobic kcals from the questionnaire (4) 4W anaerobic kcals from e-mail (5) 6M aerobic kcals from the questionnaire (6) 6M anaerobic kcals from the questionnaire	Exercise Data
(7) Test anxiety score (8) Perceived validity of SCET score	Situational Factors
(9) Trait anxiety score (10) Achievement striving score	Personality Facets

An analysis of variance (ANOVA) was performed on different subpopulations of interest. The sequential sum of squares (SSS) was determined for each significant predictor of VO_{2max}. The SSS shows the incremental reduction in the sum of squares error as each variable is brought into the model. The SSS shows how much variance a variable explains when entered into the regression model (assuming the other variables are entered in the regression model). The total sum of squares (SST) measures the total variance (explained and unexplained) in a regression model. The ratio of SSS to SST measures the proportion of variance explained by a given variable relative to the total amount of variance.

Also, independent sample t-tests were applied to the ΔVO_{2max} scores for different subsets of the population to test for significant differences. T-tests were also used to identify differences between the e-mail participants and all other participants.

IV. Results and Analysis

Descriptive Statistics

There were 209 participants in the survey. However, due to incomplete data, only 195 questionnaires (188 men and 16 women) were useable. The men ranged in age from 21 to 48, and the women's ages ranged from 23 to 49. The mean age was 30.5 with a standard deviation of 5.6 years. ΔVO_{2max} scores (ml/kg/min) ranged from -8 (failing) to 28 (passing) with a mean of 7.5 and a standard deviation of 7.8. The 16 females in the study had significantly higher ($p = 0.032$) mean ΔVO_{2max} scores (10.9 ml/kg/min) than the males (6.8 ml/kg/min). However, the males reported expending significantly more ($p = .008$) kcals (2,031 kcal/wk) than the females (1,100 kcal/wk) during the four-weeks prior to the test. The small number (n=16) of female participants makes more detailed analysis of these gender differences difficult.

Table 2 below shows descriptive statistics for all variables evaluated and their correlation with ΔVO_{2max}.

Table 2 - Descriptive Statistics for Regression Variables

	Mean	Standard Deviation	Correlation with ΔVO_{2max}
Aerobic kcal (4W) kcal/week	2065	1665	.33*
Aerobic kcal (6M) kcal/week	2094	1710	.22*
Anaerobic kcal (4W) kcal/week	582	976	-.08
Anaerobic kcal (6M) kcal/week	648	1043	-.06
Test Anxiety	2.7	1.39	-.49*
Perceived Validity	5.5	3.50	.20*
Trait Anxiety	3.2	.96	.03
Achievement Striving	5.0	.60	-.06

*p<.01

As shown in Table 2, it can be seen that the 4W aerobic data was more highly correlated with ΔVO_{2max} than the 6M aerobic data. The higher correlation of the 4W data suggests that the 4W data is more influential on ΔVO_{2max}. For this reason, the 4W data was used in all analyses. A complete correlation table of all variables can be found in Appendix C. Examination of Appendix C reveals some significant, albeit low, correlations between variables. When variables are correlated to each other, muliticollinearity becomes an issue. Several tests were run to test for multicollinearity, and despite the low correlations among some variables, there were no apparent problems with multicollinearity in any of the analyses performed.

The four research questions posed in Chapter II will be answered in the following sections. A review of those questions is shown below.

(1) Is there a relationship between situational factors and SCET VO_{2max}?
(2) Is there a relationship between personality and SCET VO_{2max}?
(3) Is there a relationship between exercise activities and SCET VO_{2max}?
(4) How much variance in SCET VO_{2max} scores is explained by the variables in questions 1-3?

<u>Anxiety and ΔVO_{2max}</u>

As shown in Table 2, there is a significant negative correlation between test anxiety and ΔVO_{2max} ($r =\ 0.49$; $p < 0.01$). That is, the more anxious a person was about the test, the lower he or she scored on the SCET. However, trait anxiety was not significantly related to ΔVO_{2max} ($r = 0.03$; $p < 0.05$). Figures 1 and 2 visually demonstrate the relationships between anxiety and ΔVO_{2max}. It can be concluded that having an anxious personality does not affect performance on the SCET.

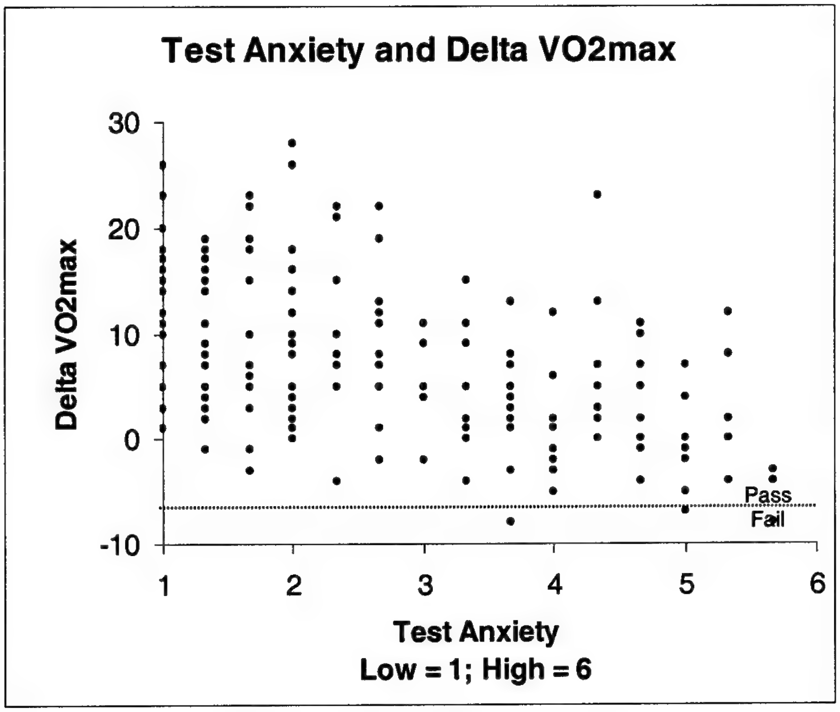

Figure 1 - Test anxiety and ΔVO_{2max}

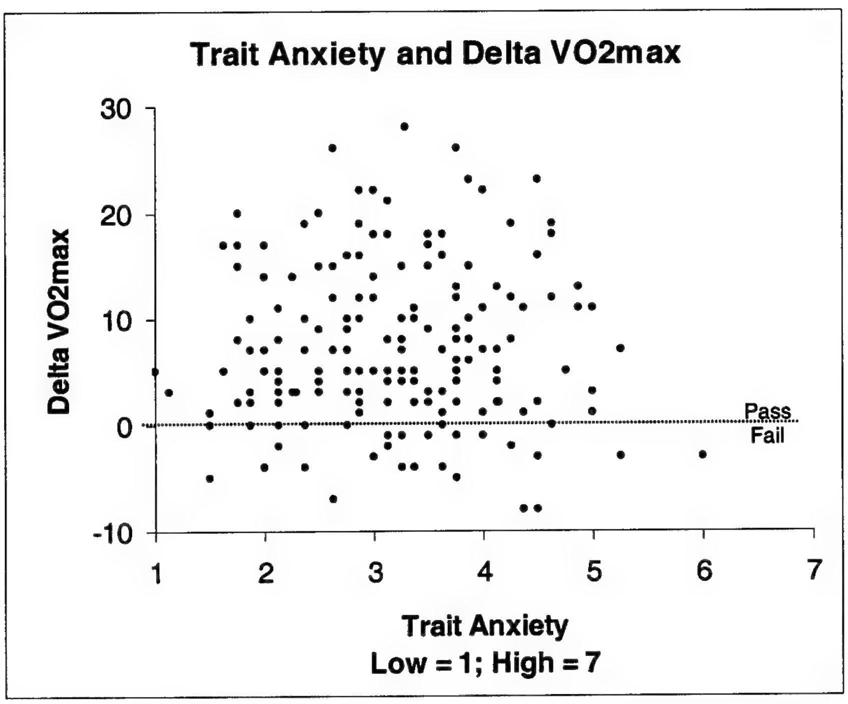

Figure 2 - Trait anxiety and ΔVO_{2max}

Figure 3 shows the relationship between ΔVO_{2max} and test anxiety for runners and cyclists. Individuals were considered runners or cyclists if they ran or cycled a majority ($\geq$ 50%) of their total aerobic caloric expenditure. There was a significant negative correlation for runners between test anxiety and ΔVO_{2max} ($r = -0.51$; $p < 0.01$). There was also a significant negative correlation for cyclists ($r = -.50$; $p < 0.05$). These correlations suggest that for runners and cyclists, higher test anxiety levels generally result in lower SCET results.

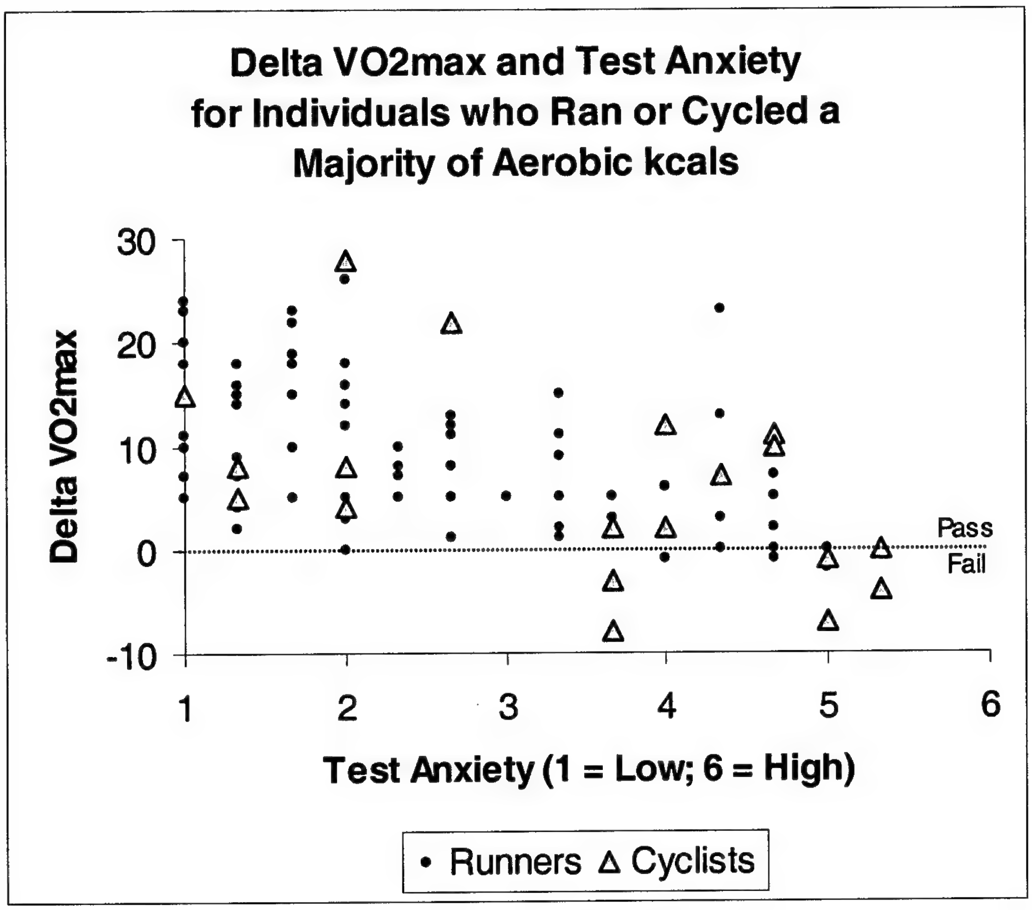

Figure 3 - Test anxiety and ΔVO_{2max} for Runners and Cyclists

Anxiety, SCET History, and ΔVO_{2max}

A correlational analysis was performed to see if there was any relationship between SCET performance history (previous failures or invalid scores), past placement in the SFIP or the MFIP, test anxiety, and ΔVO_{2max}. Table 3 shows the correlations between these variables. Past failure and invalids refer to whether the participant ever received a below passing or invalid score on the SCET. Past SFIP and MFIP refer to whether the participant reported being in one of the two mandatory fitness programs.

Table 3 - Correlations Between Test Anxiety, ΔVO_{2max}, and SCET Performance History

	ΔVO_{2max}	Test Anxiety	Past Failure	Past Invalid	Past SFIP
Test Anxiety	-.490**				
Past Failure	-.485**	.432**			
Past Invalid	-.117	.332**	.081		
Past SFIP	-.282	.241**	.500**	.102	
Past MFIP	-.159	.101	.237**	.112	.441**

**$p < 0.01$

Table 3 shows several significant correlations among the variables. Past failures is significantly negatively correlated with ΔVO_{2max} and test anxiety. Thus, participants who reported failing the SCET in the past, tended to score lower on the SCET and report high levels of anxiety. The lower SCET scores received by individuals who had failed the SCET in the past may be the result of increased HRs from higher levels of test anxiety. Past failures are also significantly correlated with past placement in both the SFIP and MFIP. This was expected because failing the SCET often results in the member's placement into these programs.

Past invalid SCET scores and past placement in the SFIP are both significantly correlated with test anxiety. This indicates that individuals who received an invalid score in the past tended to report higher levels of test anxiety, and individuals who were in the SFIP in the past tended to report higher levels of test anxiety. However, there was not a significant correlation between past placement in the SFIP and ΔVO_{2max}, suggesting that the higher levels of anxiety did not play a role in SCET VO_{2max} estimation.

Exercise Activities and ΔVO_{2max}

Figure 4 shows the means and standard deviations of ΔVO_{2max} for runners, cyclists, and individuals who reported no aerobic activity. Individuals were grouped according to the percentage of kcals expended in the activities shown in Figure 4. To correct for people who participate in multiple exercise activities, an individual was included in the activity only if he or she reported 50% or more of the their total aerobic caloric expenditure from the particular activity. For example, if a participant reported 50% or more of their total aerobic kcals from running, they were added to the running group. Participants who reported zero aerobic activity were placed in the no aerobic activity group. Table 3 summarizes the independent sample t-tests performed on the groups shown in Figure 4.

Figure 4 shows that the average ΔVO_{2max} for runners was 4.7 ml/kg/min higher ($p < 0.01$) than individuals who reported no aerobic activity. There were no significant differences in mean ΔVO_{2max} between any other groups in Figure 4.

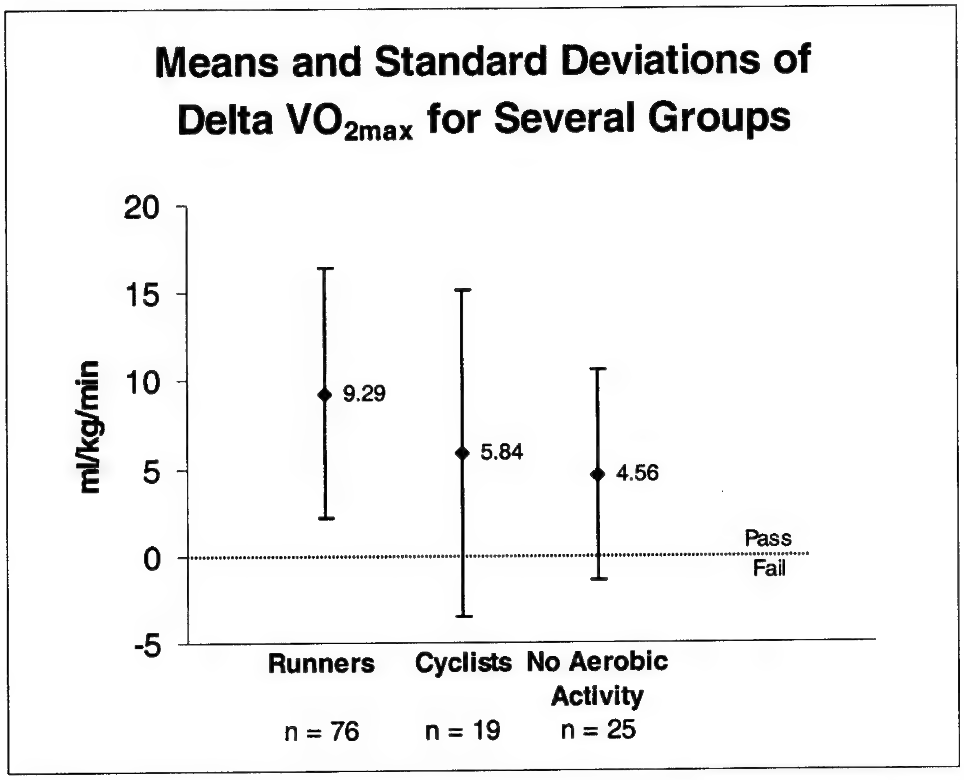

Figure 4 - Means and Standard Deviations of ΔVO_{2max} for Various Groups

Even though the majority of each participant's exercise was used to determine which aerobic group they belonged to, some analysis was performed on groups using the total aerobic kcal expenditure. To determine whether individuals who increased aerobic activity (total aerobic kcals) four weeks prior to the SCET performed better on the SCET, independent t-tests were conducted on three groups. The three groups consist of participants who were exercising during both time periods. Individuals whose aerobic activity level was zero in either time period were not included in this analysis. The three groups analyzed are as follows:

(a) individuals who reported aerobic kcals during the 6M period and increased activity during the 4W period

(b) individuals who reported aerobic kcals during the 6M period and decreased activity during the 4W period
(c) individuals who remained active, but did not change their activity level between the two periods

There was a significant increase in ΔVO_{2max} of 4.5 ml/kg/min ($p < 0.01$) for group (a) over group (b). There were no differences in ΔVO_{2max} between group (a) and (c) and group (b) and (c). Thus, increasing 4W aerobic activity does not improve SCET performance compared to individuals who maintain the same level of aerobic activity during the four weeks prior to the SCET. Furthermore, decreasing aerobic activity during the four weeks prior to the SCET does not result in lower SCET results compared to individuals who maintain their aerobic activity during the four weeks prior to the SCET. However, increasing 4W aerobic activity will result in higher mean ΔVO_{2max} scores than individuals who decrease aerobic activity prior to the SCET. This analysis suggests that there is no advantage to increasing exercise during the 4 weeks prior to the SCET as long as the current level of exercise is maintained.

Regression and ANOVA

The influence on ΔVO_{2max} of each of the variables was evaluated through multiple stepwise regression. For all regressions, the variables entered were:

4W aerobic kcals
4W anaerobic kcals
Test anxiety score
Perceived validity score
Trait anxiety score
Achievement striving score

For the regressions run on runners and cyclists, running or cycling kcals were used. For runners and cyclists the influence of running or cycling on ΔVO_{2max}, not the total aerobic caloric expenditure, was of interest to see the direct influence each activity had on ΔVO_{2max}.

When all participants were included in the regression analysis (n = 195) variables with the most significant influence on ΔVO_{2max} were (in order of significance) test anxiety, total aerobic kcals, and trait anxiety ($r^2 = 0.37$). An ANOVA reveals that for the group as a whole, test anxiety explains 24% of the variance in ΔVO_{2max} scores and aerobic activity explains only 10%. The following pie chart, Figure 5, shows the proportions of variance each of the significant predictors explains.

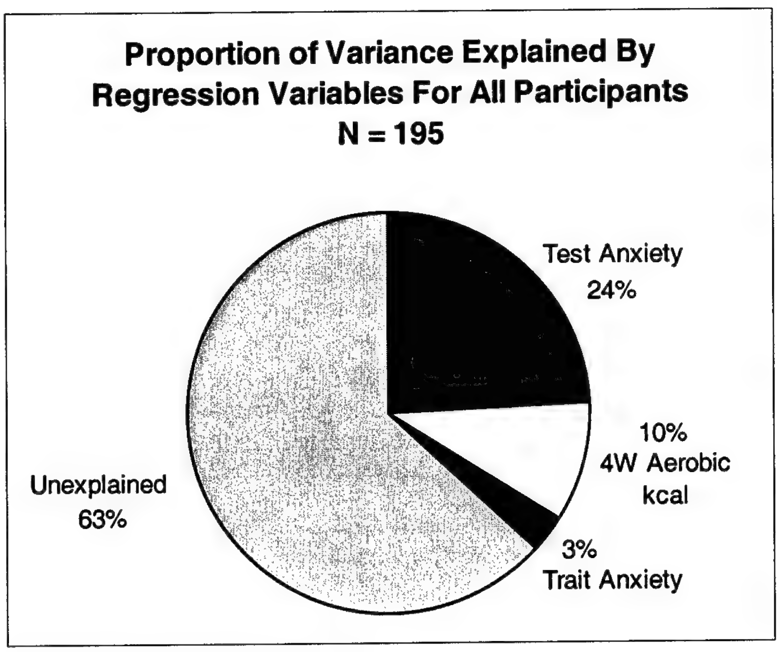

Figure 5 - Proportion of Variance Explained For All Participants

Because some exercise data was collected via an e-mail survey, a separate regression was run on the e-mail group (n = 48), which was a subset of the whole group sampled. The breakdown of variance in scores can be seen in Figure 6. For the e-mail survey participants aerobic exercise explains the most variance (28%) in ΔVO_{2max} followed by test anxiety (23%).

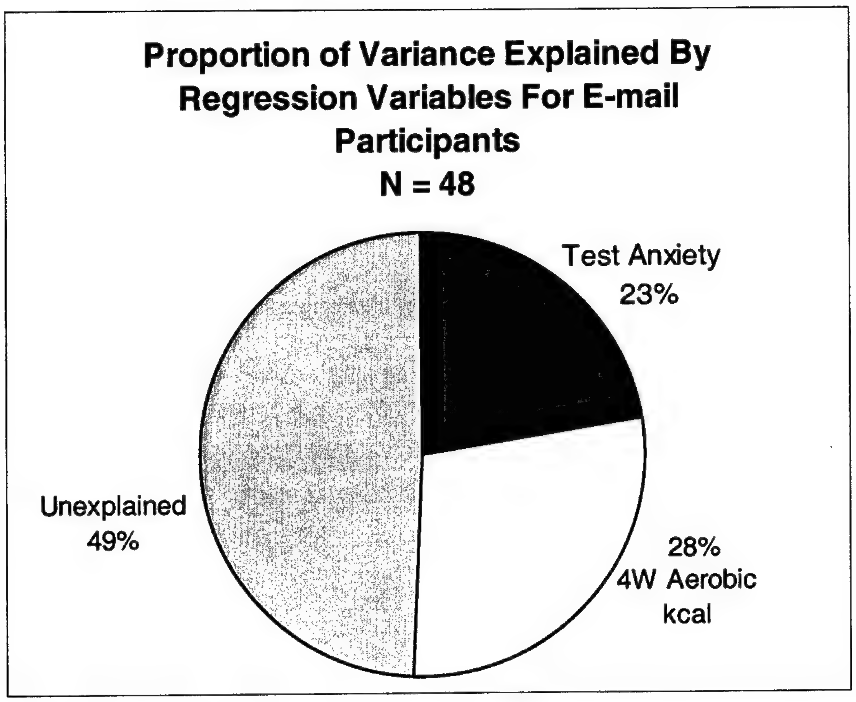

Figure 6 - Proportion of Variance Explained for E-mail Participants

A regression run on all participants who did not participate in the e-mail study (n = 148) revealed findings very similar to the findings for the entire sampled population (excluding the e-mail participants). Results for the whole group excluding the e-mail participants (n = 148) are shown in Figure 7. Test anxiety explained the most variance (24%), followed by aerobic activity (8%) and trait anxiety (2%).

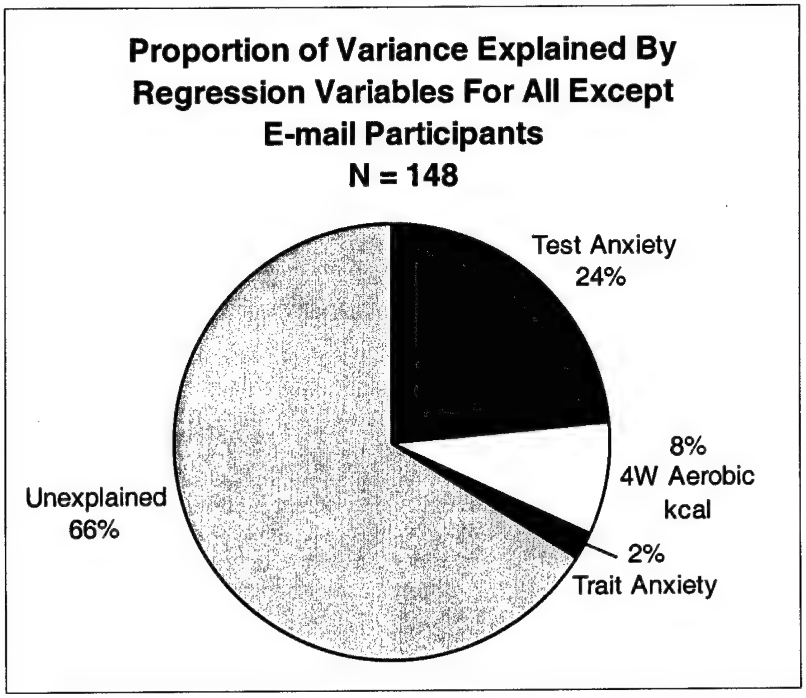

Figure 7 - Proportion of Variance Explained for All Except E-mail Participants

The differences between the e-mail group and the rest of the participants could possibly be explained by exploring several possible theories. Perhaps the e-mail group was different in some way that made exercise a bigger player in performance on the SCET. Maybe the e-mail group exercised more, participated in a wider range of exercise activities, had higher mean ΔVO_{2max} values, or had fewer failures. Independent sample t-tests run on the two groups revealed a significant difference in level the anaerobic kcal expenditure. The e-mail participants expended an average of 284 anaerobic kcals more than the non-email participants ($p < 0.05$). There were no other significant differences between the two groups. There were also no differences in the percentage of runners and cyclists in both groups.

Another plausible explanation is that the exercise data for the e-mail group was more accurate because it was taken weekly. Better recall in the e-mail group may account for the increased influence of aerobic exercise on ΔVO_{2max} (28% versus 8%). Another independent sample t-test on the e-mail group revealed no significant difference between the aerobic kcals reported via e-mail and the aerobic kcals reported via the questionnaire. For the e-mail group, this suggests that the 4 week recall was as good as the 1 week recall. However, these results do not necessarily mean that the 4-week recall was as good as the 1-week recall for the rest of the sampled population. The e-mail group's responses could have been more accurate because they were participating in the e-mail study, which made them more aware of their past activities when they completed the questionnaire.

<u>Runners</u>

The entire population was divided into several groups to gain insight into the influences on ΔVO_{2max}. A summary of the regressions performed can be found in Appendix D. The first group examined was runners. A regression was performed including anyone who reported running for any portion of his or her workout expenditure (individuals who ran > 0% of total aerobic kcals). This group included 120 participants. Figure 8 summarizes the results of the analysis of variance for this group. Again, test anxiety explained the most variance in ΔVO_{2max} scores (31%). Kilocalories burned running only explained 3%, and trait anxiety explained 4% of the variance.

Figure 9 shows the proportions of variance explained for individuals who spent the majority (≥ 50%) of their aerobic kcals running (n = 76). These results are similar to those seen in Figure 8 and are similar to results from the entire group surveyed.

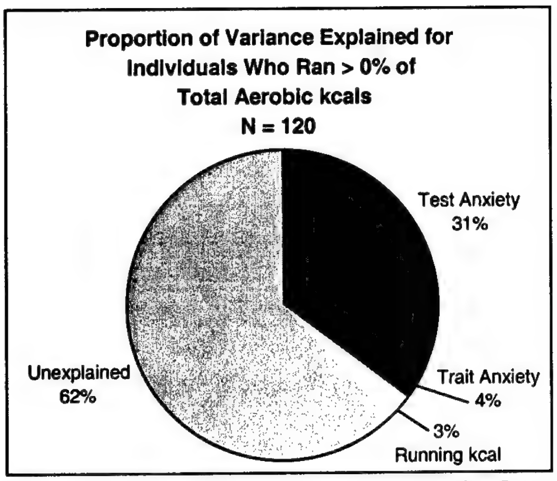

Figure 8 - Proportion of Variance Explained for Individuals Who Ran > 0% of Total Aerobic kcals

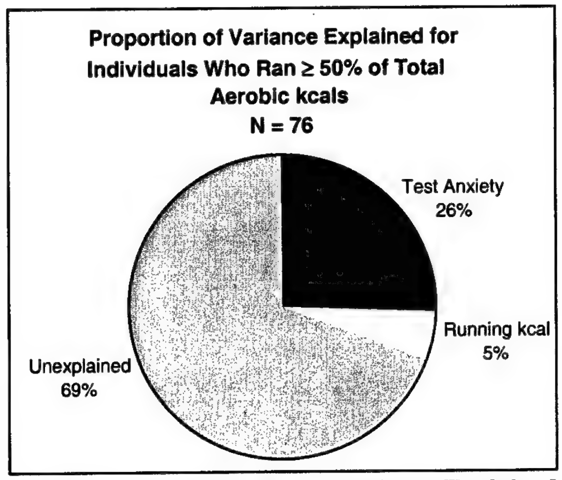

Figure 9 - Proportion of Variance Explained for Individuals Who Ran at least 50% of Total Aerobic kcals

These results suggest that for runners, running has only a small influence on SCET ΔVO_{2max}. An independent sample t-test revealed that people who ran any amount at all scored an average of 4.61 ml/kg/min higher than people who did not run ($p < 0.01$). These results suggest that there is some unknown aspect shared by individuals who run that allows them to perform better on the SCET. Any amount of running seems to improve SCET performance over those who do not run, but there is little to no difference in results for those who run any amount at all (> 0%) versus those who run a majority of their aerobic kcals (≥ 50%). For both of these groups, test anxiety had the greatest influence on SCET performance.

Cyclists

Another regression was run on the subset including anyone who cycled any amount--individuals who cycled > 0% of aerobic kcals (both stationary and outdoor cycling included; n = 60). Results from this can be found in Figures 10. Test anxiety again explained the most variance in scores (28%) followed by the amount of kcals expended cycling (11%) and trait anxiety (10%). This group was narrowed further by examination of individuals who cycled 50% or more of their aerobic kcals (n = 19). Figure 11 shows results from this group. The results from this group show that kcals expended cycling were the only predictor of ΔVO_{2max}, explaining 53% of the variance.

The breakdown of explained variance for individuals who cycle any amount (> 0% of total aerobic kcals) closely resembles the group as a whole, with test anxiety explaining most of the variance and exercise explaining only about 10%. It can be concluded that cycling any amount less than 50% of the total aerobic kcals does not significantly increase the influence of exercise on SCET performance.

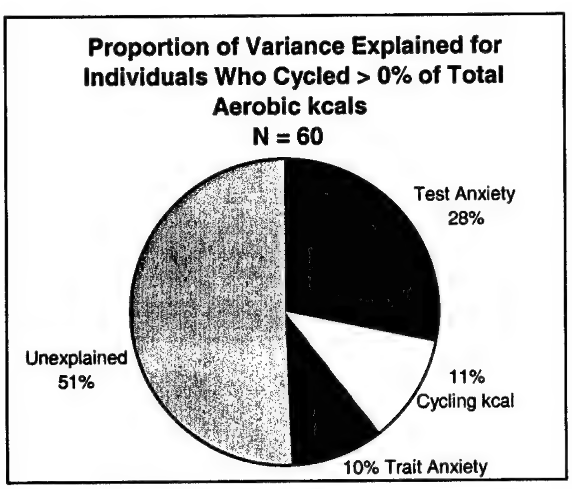

Figure 10 - Proportion of Variance Explained For Individuals Who Cycled > 0% of Total Aerobic kcals

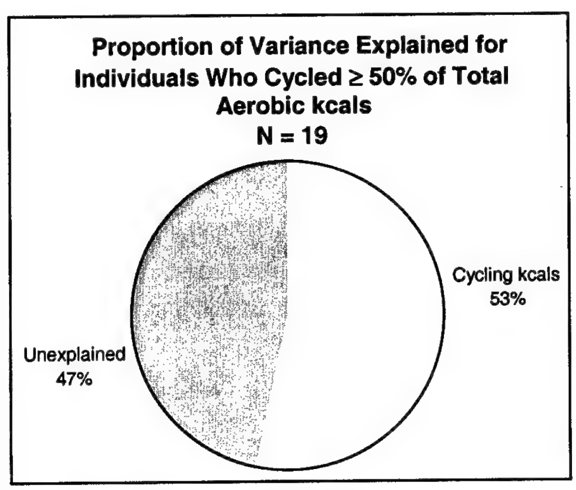

Figure 11 - Proportion of Variance Explained For Individuals Who Cycled 50% or More of Total Aerobic kcals

For individuals who cycle a majority of their aerobic kcals (at least 50%), exercise is the only influence on SCET performance. For individuals who cycle at least 50% of their aerobic kcals, the SCET more accurately predicts aerobic fitness. This gives cyclists a great advantage on the SCET because exercise, not anxiety, has the largest influence on results. These results are very interesting compared to individuals who run a majority of their aerobic kcals (at least 50%). There was little difference in what influences SCET performance between running any amount and running a majority of aerobic kcals. For the cyclists, however, there was a very large difference in what influences SCET performance between cycling any amount and cycling a majority of aerobic kcals.

V. Discussion

There were two main purposes of this study. The first was to examine the relationship between different exercise activities and performance on the SCET. The second was to examine other factors such as anxiety and personality, which may influence ΔVO_{2max}.

Exercise and ΔVO_{2max}

From the results presented in this study, it can be concluded that running was the only activity where SCET performance was significantly better than that of sedentary individuals. Furthermore, for most aerobic activities test anxiety explained the most variance and was the greatest predictor of ΔVO_{2max}. When the majority of kcals were expended cycling, the kcals cycled had a large influence (53%) on SCET performance, and anxiety did not play a role in SCET performance.

This study's results suggest that certain types of exercise such as running have little influence on determination of SCET ΔVO_{2max}. Individuals who expended more than 4000 kcals aerobically increased their mean ΔVO_{2max} by only 6.63 ml/kg/min over sedentary individuals. Runners who expended 50% or more of their aerobic kcals running increased their mean ΔVO_{2max} by 4.73 ml/kg/min over sedentary individuals.

An increase of 6 ml/min/kg on the SCET is small relative to the amount of exercise performed. One would expect a greater difference in ΔVO_{2max} between sedentary individuals and those who exercised 4000 kcals or more aerobically per week.

An aerobic expenditure of 4000 kcals per week (estimated by the MET conversion explained in Chapter III) is roughly the equivalent of a 30-year-old male running 30-40 miles per week -- an endurance-trained athlete. The VO_{2max} of an endurance-trained male runner ranges from 65 to 80 ml/kg/min (Thoden, 1991:117). The mean VO_{2max} for males who expended at least 4000 kcals was only 44 ml/kg/min. For very aerobically fit individuals, VO_{2max} appears to be significantly underestimated. This agrees with prior results from this study indicating that non-cycling aerobic exercise plays a minor role in SCET VO_{2max} estimation.

For the group of inactive males surveyed, mean VO_{2max} was 36.6 ml/kg/min. For untrained males, VO_{2max} ranges from 38 to 52 ml/kg/min (Thoden, 1991:117). Thus, for the group of sedentary males, VO_{2max} was only slightly underestimated.

<u>Other Influences on ΔVO_{2max}</u>

Several factors were tested to see if they influenced ΔVO_{2max}. Repeatedly, two main factors surfaced as the most significant predictors of ΔVO_{2max}: test anxiety and aerobic exercise. This may be explained by the body's responses to immediate stress (test anxiety), specifically an increased HR that would result in VO_{2max} underestimation. It is interesting that test anxiety had a dominant influence on SCET performance, but trait anxiety did not in most cases. Having an anxious personality does not seem to increase the body's response to test anxiety and it has little affect on SCET performance.

Figure 12 shows the relative amounts of variance in ΔVO_{2max} scores explained by test anxiety and aerobic exercise for all individuals (n = 195), runners (n = 76), and cyclists (n = 19). The groups listed included individuals who reported expending at least

50% of total aerobic kcals in the particular activity. For the group including all participants, the amount of variance explained by all aerobic activities reported is shown.

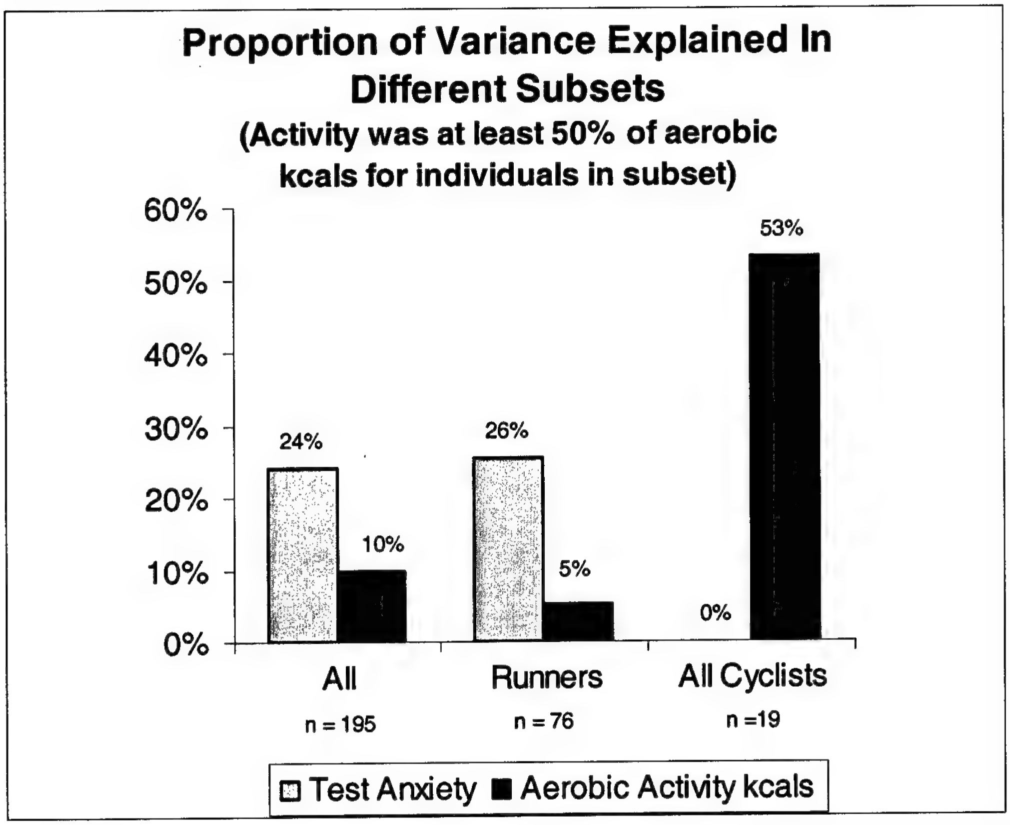

Figure 12 - Proportion of Variance Explained in Different Subsets of the Population Sampled

For the groups in Figure 12, test anxiety was most influential on SCET ΔVO_{2max} except in the cyclist group. In fact, for the cyclist group, test anxiety had zero influence on SCET performance. However, kcals cycled had a very large influence on SCET performance, while kcals expended had only a little influence on performance for the runners and the group as a whole. Furthermore, the cyclist group was the only group evaluated in which the explained variance was greater than the unexplained variance.

There were only two differences found between the runner and cyclist groups of Figure 12. Although the results for the runners were heavily influenced by test anxiety (26%), the cyclists reported significantly higher mean test anxiety scores than the runners. Thus, despite the fact that the cyclists were more anxious about the SCET, test anxiety did not influence results. The other difference between the groups is the obvious difference in main aerobic activity chosen: cycling and running. The results suggest that when cycling is the major portion of total aerobic caloric expenditure, their results are more reflective of cycling expenditure. Cyclists train certain muscles and muscle fibers that may give them a training advantage over runners when taking the SCET.

Limitations

Some limitations to this study are the population studied, the relatively small groups examined, and the self-reported activity. Because AFIT is a unique group, results may not necessarily reflect the rest of the Air Force. Also, there were only 16 women participants. A larger group of women would have enabled some comparisons between males and females. The small groups of cyclists could also be a source of error. Larger groups need to be examined before any conclusions can be made about which activities result in increased performance on the SCET. Self-reported exercise could be another source of error. Perhaps four-week recall is not very accurate. It would have been better to have all participants log their exercise continuously for several weeks prior to the assessment, but this was not done in this study because of the possible influence this may have on anxiety.

It would have been helpful to examine other exercise activities more closely. For example, does swimming or playing racquetball improve results? In this study, these groups were too small to evaluate. It would have also been interesting to examine a larger group of endurance-trained athletes. It is recommended that this study be conducted on a larger population more representative of the Air Force. More exercise activities need to be examined, and larger groups of runners, cyclists, and sedentary individuals need to be evaluated.

Conclusions

For the sampled population of AFIT students, the validity of the SCET is questionable due to the large influence of test anxiety. The results of this study suggest that by controlling anxiety about the test, one could significantly improve his or her score. The results also suggest that SCET performance can be improved by expending a majority of aerobic kcals cycling.

Participating in cycling as a majority of aerobic exercise appears to increase the influence of exercise during the SCET over other activities such as runners. This may be because cycling trains the same muscles used in the SCET, giving cyclists an advantage over runners.

These findings give reasons to question the validity of using the SCET to test fitness in the Air Force. If the SCET is supposed to test fitness, the amount of exercise should have been the most significant predictor of ΔVO_{2max}. However, this was true only for individuals who cycled a majority of their aerobic kcals. Research has shown that the test is reliable, and results are correlated well with maximally determined VO_{2max}.

However, because of the importance of passing the SCET in the Air Force, other factors such as test anxiety appear to significantly influence SCET results. When an individual is anxious about the SCET, the test does not appear to assess only the fitness of the individual.

From this point, it is recommended that the SCET be re-evaluated by the Air Force. Perhaps there is a way to change the SCET to incorporate the large role of test anxiety. Some HAWCs, such as the Wright-Patterson HAWC, offer relaxation rooms for individuals to use prior to taking the SCET. An increase in education about factors that influence SCET results may help improve SCET scores. For example, educating people about the large role of anxiety could help them to see the importance of staying calm during the test. It may also encourage individuals to use the relaxation rooms before the SCET. Some individuals, especially those who are in danger of failing the SCET, may benefit by knowing the possible advantages of cycling as a main aerobic activity to passing the SCET.

If the SCET cannot be altered to incorporate the large role of anxiety other alternatives to the SCET can be offered. Perhaps individuals should be given the choice of either taking a submaximal treadmill test or a submaximal cycle ergometer test. This way, both runners and cyclists could take advantage of their training when taking the submaximal fitness test. There is evidence that the method of VO_{2max} testing should be compatible with the individual's training method (Basset and Boulay, 2000:14; Franklin, 2000:71). Another option would be to allow individuals to take the 1.5-mile run test in place of the SCET. Giving AF members a choice of fitness testing allows them to choose

the test that will be most advantageous to them due to the aerobic activities they participate in.

Appendix A – Questionnaire

CYCLE ERGOMETRY FITNESS ASSESSMENT QUESTIONNAIRE

Purpose: The purpose of this study is to investigate the relationship between exercise, anxiety, and personality and the Air Force cycle ergometry fitness assessment. Your answers to this questionnaire will provide data for an Air Force Institute of Technology (AFIT) thesis.

Participation: We would greatly appreciate your completing this survey. Your participation is COMPLETELY VOLUNTARY. However, your input is important for us to understand the cycle ergometry fitness test. You may withdraw from this study at any time without penalty, and any data that may have been collected from you.

Confidentiality: ALL ANSWERS ARE STRICTLY CONFIDENTIAL. No one outside the research team will ever see your questionnaire. Findings will be reported at the group level only. Reports summarizing trends in large groups may be published.

The first initial of your last name and the last four numbers of your Social Security Number (SSN) are collected to match questionnaires to cycle ergometry assessment scores. After scores and questionnaire data are matched, all personal information will be deleted from the data file.

Copyright Information: Some of the items on this questionnaire are reproduced by special permission of the publisher, Psychological Assessment Resources, Inc., 16204 North Florida Avenue, Lutz, Florida 33549, from the NEO Personality Inventory-Revised, by Paul Costa, and Robert McCrae, Copyright 1978, 1985, 1989, and 1992 by PAR, Inc. Further reproduction is prohibited without permission of PAR, Inc.

Sponsor: The Air Force Cycle Ergometry Program Office is the official sponsor for this research. The researchers have full cooperation from the WPAFB Health And Wellness Center (HAWC) to administer the questionnaire after cycle ergometry testing. This questionnaire has been approved by the Air Force Personnel Center (USAF SCN 00-87).

Contact Information: If you have any questions or comments about the survey, you can contact either of the following individuals:

Lt Heather Ferlin
AFIT/ENS Bldg 640
2950 P Street
WPAFB OH 45433
255-3636 x6215
heather.ferlin@afit.af.mil

Major Peter LaPuma
AFIT/ENV Bldg 640
2950 P Street
WPAFB OH 45433
255-6565 x4319
peter.lapuma@afit.af.mil

Sex ____________ Weight ____________ pounds
Age ____________ Height ____________ inches
Smoker? Yes No

First letter of last name ____________
Last 4 numbers of SSN ____________

Please fill in the requested information for each activity you regularly participated in during the timeframe indicated.

Present ◄——► Past 1 Month

	Sessions per week	Average minutes per session	Average miles per session
Running			
Walking			
Outdoor Cycling			
Stationary Cycling (see next section)			

Stationary Cycling Fill in as much as possible

		Calories/session
		Miles/hour
Bike Type (specify below)		Watts
		Bike Level

(include only actual time lifting)	Sessions per week	Average minutes per session	Intensity Lo/Med/Hi (pick one)
Weight Lifting (upper body)			
Weight Lifting (lower body)			
Aerobics			
Stair Stepper			
Basketball (game play)			
Swimming			
Racquetball			
Rollerblading			
Other (specify below)			

☐ I have not participated in exercise during this timeframe

Past 1 Month ◄——► Past 6 Months

☐ Check if same as present to 1 month, otherwise fill in below	Sessions per week	Average minutes per session	Average miles per session
Running			
Walking			
Outdoor Cycling			
Stationary Cycling (see next section)			

Stationary Cycling Fill in as much as possible

		Calories/session
		Miles/hour
Bike Type (specify below)		Watts
		Bike Level

(include only actual time lifting)	Sessions per week	Average minutes per session	Intensity Lo/Med/Hi (pick one)
Weight Lifting (upper body)			
Weight Lifting (lower body)			
Aerobics			
Stair Stepper			
Basketball (game play)			
Swimming			
Racquetball			
Rollerblading			
Other (specify below)			

☐ I have not participated in exercise during this timeframe

CYCLE ERGOMETRY FITNESS ASSESSMENT QUESTIONNAIRE

Circle your response to the questions below based on the following scale.

1 Strongly Disagree	2 Disagree	3 Slightly Disagree	4 Slightly Agree	5 Agree	6 Strongly Agree

1.	I felt relaxed about the cycle ergometry test just before I took the test.	1	2	3	4	5	6
2.	I believe the cycle ergometry test is a valid test of my aerobic fitness level.	1	2	3	4	5	6
3.	I get winded when walking up a flight of stairs (about 20 steps).	1	2	3	4	5	6
4.	I was anxious about the fitness test the week prior to the test.	1	2	3	4	5	6
5.	I can improve my score on the cycle ergometry fitness assessment if I exercise more frequently.	1	2	3	4	5	6
6.	The cycle ergometry fitness assessment is a good predictor of my aerobic fitness level.	1	2	3	4	5	6
7.	I was confident I would pass the cycle ergometry fitness assessment.	1	2	3	4	5	6
8.	There is little I can do to improve my performance on the cycle ergometry fitness assessment.	1	2	3	4	5	6
9.	I can run 2 miles within 25 minutes without much difficulty.	1	2	3	4	5	6
10.	I was anxious about the possibility that I would not pass the fitness assessment.	1	2	3	4	5	6

11.	Have you ever received a below passing score on the cycle ergometry test?	Yes	No	Year(s) ______
12.	Have you ever received an invalid score on the cycle ergometry test?	Yes	No	Year(s) ______
13.	Have you ever been in the Self-Directed Fitness Improvement Program (SFIP)?	Yes	No	Year(s) ______
14.	Have you ever been in the Monitored Fitness Improvement Program (MFIP)?	Yes	No	Year(s) ______

Enter the numerical score you received today on the cycle ergometry fitness assessment and circle the final result of your test.	Score ______	Pass	Invalid	Fail

<u>Circle</u> your response to the questions below based on the following scale.

1 Strongly Disagree	2 Disagree	3 Slightly Disagree	4 Neither Agree nor Disagree	5 Slightly Agree	6 Agree	7 Strongly Agree

15.	1	2	3	4	5	6	7
16.	1	2	3	4	5	6	7
17.	1	2	3	4	5	6	7
18.	1	2	3	4	5	6	7
19.	1	2	3	4	5	6	7
20.	1	2	3	4	5	6	7
21.	1	2	3	4	5	6	7
22.	1	2	3	4	5	6	7
23.	1	2	3	4	5	6	7
24.	1	2	3	4	5	6	7
25.	1	2	3	4	5	6	7
26.	1	2	3	4	5	6	7
27.	1	2	3	4	5	6	7
28.	1	2	3	4	5	6	7
29.	1	2	3	4	5	6	7
30.	1	2	3	4	5	6	7

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Appendix B - Factor Analysis Matrices

Rotated Component Matrix

Question	Component 1	Component 2	Component 3
Test Anxiety 1 (Q1)	.863	-.185	.027
Test Anxiety 2 (Q4)	.847	-.004	.084
Test Anxiety 3 (Q10)	.894	-.053	.034
Perceived Validity 1 (Q2)	-.425	.729	-.077
Perceived Validity 2 (Q5)	.036	.845	-.044
Perceived Validity 3 (Q6)	-.362	.792	-.065
Perceived Validity 4 (Q8)	.050	.795	-.030
Perceived Fitness 1 (Q3)	.092	-.149	.695
Perceived Fitness 2 (Q7)	-.735	.179	.220
Perceived Fitness 3 (Q9)	-.112	.029	.787

Extraction Method: Principle Component Analysis
Rotation Method: Varimax with Kaiser Normalization

Component Matrix

Question	Component 1	Component 2
Trait Anxiety 1	.753	.214
Trait Anxiety 2	.658	.256
Trait Anxiety 3	.698	.266
Trait Anxiety 4	.631	.111
Trait Anxiety 5	.701	.363
Trait Anxiety 6	.642	.076
Trait Anxiety 7	.571	.074
Trait Anxiety 8	.500	.006
Achievement Striving 1	-.263	.371
Achievement Striving 2	-.266	.737
Achievement Striving 3	-.366	.762
Achievement Striving 4	.024	.592
Achievement Striving 5	-.220	.554
Achievement Striving 6	.122	.308
Achievement Striving 7	-.219	.726
Achievement Striving 8	-.401	.462

Extraction Method: Principal Component Analysis

Appendix C - Correlation Table

Correlation Table of Regression Variables

	Mean	Std. Dev.	Δ VO_{2max}	4W Aerobic	6M Aerobic	E-Mail Aerobic	4W Anaerobic	6M Anaerobic	E-Mail Anaerobic	Test Anxiety	Validity of SCET	Trait Anxiety
ΔVO2max	7.5	7.8										
4 W Aerobic	2065	1665	.330**									
6M Aerobic	2094	1710	.223**	.821**								
E-Mail Aerobic	2187	1693	.223**	.450**	.338**							
4W Anaerobic	582	976	-.075	.116	.145*	.206**						
6M Anaerobic	648	1043	-.058	.110	.152*	.175*	.908**					
E-Mail Anaerobic	692	1004	.011	.164*	.132	.432**	.624**	.574**				
Test Anxiety	2.7	1.39	-.492**	-.036	-.019	-.086	-.031	-.037	-.030			
Validity of SCET	5.5	3.5	.203**	-.175*	-.201**	-.007	-.259**	-.221**	-.228**	-.294**		
Trait Anxiety	3.2	.96	.030	-.070	-.078	.006	-.146*	-.158*	-.092	.310**	-.008	
Ach. Striving	5.0	.60	-.055	.075	.112	-.043	.166*	.119	-.035	.024	-.106	-.054

*p < 0.05 **p < 0.01

Appendix D - Regression and ANOVA Summary

Individuals Included	N	R^2	Adj R^2	SST	Significant Variables	SSS	SSS/SST
All	195	0.369	0.359	10870	Test Anxiety	2625	0.24
					Aerobic kcal	1063	0.10
					Trait Anxiety	319	0.03
Email Participants	48	0.506	0.484	2907	Email aerobic kcal	814	0.28
					Test Anxiety	657	0.23
All Except E-mail	148	0.339	0.326	7882	Test Anxiety	1867	0.24
					Aerobic kcal	652	0.08
					Trait Anxiety	156	0.02
Kcal Run > 0% of total aerobic kcal	120	0.381	0.365	6117	Test Anxiety	1882	0.31
					Trait Anxiety	273	0.05
					Running kcal	172	0.03
Kcal Run ≥ 50% of total aerobic kcal	76	0.308	0.289	3846	Test Anxiety	984	0.26
					Running kcal	199	0.05
Outdoor Cycling kcal > 0% of total aerobic kcals	22	0.583	0.540	1682	Outdoor biking kcal	566	0.34
					Validity of SCET	415	0.25
Stationary Cycling kcal > 0% of total aerobic kcals	43	0.250	0.231	2325	Test Anxiety	580	0.25
All Cycling kcal ≥ 50% of total aerobic kcal	19	0.532	0.505	1575	All Cycling kcal	838	0.53

Individuals Included	N	R^2	Adj R^2	SST	Variables	SSS	SSS/SST
All Cycling kcal > 0% of total aerobic kcal	60	0.495	0.468	3939	Test Anxiety	1117	0.28
					All Cycling kcal	433	0.11
					Trait Anxiety	401	0.10
Aerobic kcal < 2000	113	0.221	0.214	4634	Test Anxiety	1026	0.22
Aerobic kcal ≥ 2000	84	0.452	0.424	5330	Test Anxiety	1384	0.26
					Trait Anxiety	436	0.08
					Validity of SCET	308	0.06
					Aerobic kcal	250	0.05
Aerobic kcal < 4000	169	0.232	0.227	9120	Situational Anxiety	2073	0.23
					Aerobic kcal	598	0.07
					Validity of SCET	212	0.02
					Trait Anxiety	169	0.02
Aerobic kcal ≥ 4000	26	0.619	0.567	1198	Test Anxiety	403	0.34
					Trait Anxiety	232	0.19
					Aerobic kcal	106	0.09
Aerobic kcal > 0	177	0.418	0.405	9902	Test Anxiety	2533	0.26
					Aerobic kcal	943	0.10
					Trait Anxiety	420	0.04
					Validity of SCET	247	0.03
Age ≥ 30	94	0.343	0.313	5617	Test Anxiety	1173	0.21
					Aerobic kcal	366	0.07
					Validity of SCET	188	0.03
					Trait Anxiety	164	0.03
Age < 30	101	0.466	0.449	5252	Test Anxiety	1475	0.28
					Aerobic kcal	782	0.15
					Trait Anxiety	189	0.04

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Vita

Heather M. Hunn was born on Euclid, Ohio in [redacted]. She graduated from Valley Forge High School in Parma, Ohio in June 1993. She entered undergraduate studies at the University of Toledo, Ohio where she graduated with a Bachelor of Arts degree in Biology and a minor in Chemistry in June 1997. She was commissioned through AFROTC Detachment 620 at the University of Bowling Green, Ohio in June 1997.

Her first assignment was at Keesler AFB from August 1997 to August 1999. While at Keesler, she was the flight commander of the Materiel Management Flight and the Management and Systems Flight in the 181st Supply Squadron. In August 1999, she entered the Graduate School of Engineering and Management, Air Force Institute of Technology. Upon graduation, she will be assigned to Headquarters, Air Mobility Command at Scott AFB.

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14. ABSTRACT
This research investigated the influence of exercise activities, situational factors, and personality on the Air Force submaximal cycle ergometry test (SCET). Data were collected via a questionnaire administered to 209 active duty students and faculty assigned to the Air Force Institute of Technology during their required annual SCET. Stepwise multiple regression and ANOVA were used to find the proportion of variance explained by the significant predictors of SCET results for various subsets of the sampled population. For the group as a whole, self-reported test anxiety explained 24% of the variance in SCET results, while reported aerobic caloric expenditure during exercise explained only 10%. For runners, test anxiety explained 26% and calories expended running explained only 5% of the variance in SCET results. For cyclists (outdoor and stationary), calories expended cycling explained 53% of the variance, while test anxiety had no influence on SCET results. These results indicate that for non-cyclists, test anxiety plays a major role in SCET performance while aerobic exercise plays only a minor role. Non-cyclists who reported high levels of anxiety about the SCET generally received lower SCET scores. The results also indicate that cyclists have a clear advantage over individuals who participate in other exercise activities.

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